Entropy Production Rate in Stochastically Time-evolving Asymmetric Networks

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Fluctuations in parameters that are typically treated as fixed play a crucial role in the behavior of complex systems. However, to date, we lack a general non-equilibrium thermodynamic treatment of such a complex system.

To address this problem, we develop a framework in which fluctuating interactions between units of nonlinear network systems are modeled as uncorrelated colored noise (i.e., annealed disorder) with a correlation time. This approach enables us to quantify how the entropy production rate (EPR) depends on both the characteristic time-scale and the strength of the disorder. Using dynamical mean field theory we derive an exact expression for EPR at any transient time that is validated by simulations of the full non-linear dynamics. At stationarity, a relation between EPR and autocorrelation is established and then used to analytically study the particular case of linear systems.